A SYSTEM FOR CARDIOHOLTER APPLICATIONS WITH ECG TRANSMISSION BY BLUETOOTH

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ABSTRACT

In this paper we present a new medical device for cardioholter applications intended to overcome the limitations actually present in the commercial devices and to advance the state of the art. In particular we propose a system for ECG transmission by Bluetooth, embedded in a digital cardioholter with multiple leads.
The system has been designed, prototyped and tested at the Electronic Devices Laboratory (Electrical and Information Engineering Department) of Polytechnic University of Bari, Italy, within a biomedical researcher program, sponsored by Italian Government.

KEYWORDS: *Bioelectronics, Electronic Medical Devices, Health Care Management Systems, Electrocardiogram Monitoring, Cardioholter, Prototyping and Testing.*

I. INTRODUCTION

Today the most used tape-recorder type electrocardiographs for the long term registration provide the acquisition of two or three channels thus allowing the detection of a limited number of pathologies and missing crucial details relevant to the morphology of the heart pulse and the related pathologies, given only by a static electrocardiogram (ECG) executed in the hospital or in medical centres [1] [2].
In this brief paper we present a new medical device for cardioholter applications intended to overcome the above limitations and to advance the state of the art.
In particular we propose a system for ECG transmission by Bluetooth [3], embedded in a digital cardioholter with multiple leads.
The system has been designed, prototyped and tested at the Electronic Devices Laboratory (Electrical and Information Engineering Department) of Polytechnic University of Bari, Italy, within a biomedical researcher program, sponsored by Italian Government [4-6].
The paper is organized in the following way: Section 2 outlines the description of the proposed system for ECG transmission, including the experimental results, whereas in Section 3 we have reported the conclusions.

II. THE PROPOSED SYSTEM FOR ECG TRANSMISSION

As we have already written, the most used tape-recorder type electrocardiographs for the long term registration provide the acquisition of two or three channels thus allowing the detection of a limited number of pathologies and missing crucial details relevant to the morphology of the heart pulse and the related pathologies.
Moreover, the sampling frequency for the analog to digital conversion of the signal, for the best known portable ECG, is typically lower than 200 Hz, thus missing important medical data carried out by the electrocardiograph signal.
Finally, the most used medical devices for long term registration (holter) of cardiac activity are generally so uncomfortable especially due to their dimensions.

In order to overcome these limitations, we have designed a microcontroller-based device allowing data from up to 12 channels to be stored thus providing the diagnostic capabilities of the static ECG together with the wearability and the long term registration of the cardiac activity.
The system core is composed by:

1. multiplexed internal ADC with a 12 bit resolution,
2. 8K bytes Flash/EE program memory
3. 32 Programmable I/O lines
4. SPI and Standard UART.

Normal, idle and power-down operating modes allow for flexible power management schemes suited to low power applications.
Thanks to its specific sensors, embedded in a kind elastic band, it is possible to place on the thorax many electrodes without reducing the movement potentials.
Moreover, the elastic band is provided with a wireless module (Bluetooth) to send the data to the recorder unit.
The storage support is a flash card. Therefore, the new system is miniaturised and results more comfortable than the commonly used tape-recorder type portable electrocardiographs.
Fig. 1 shows the prototyped electrocardiograph recorder/storage unit.

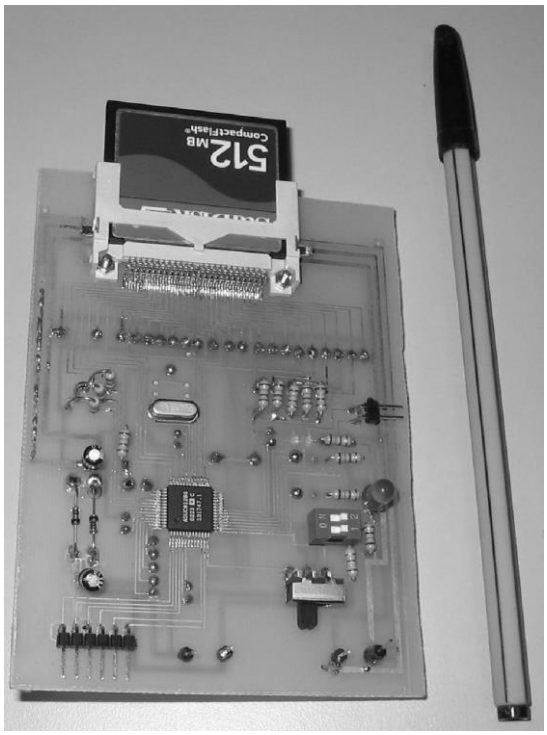

Figure 1. The realized prototype of the new electrocardiograph receiving unit.

The small dimensions are remarkable. In fact the device of Fig. 1 has been planned using SMD components.
The management software to data-download has been properly developed by the us, being it custom for this application. It receives the data from the electrocardiograph and allows to store/plot them.
In particular, the management software allows to view/plot one or more channels, to make a real-time automatic analysis of the incoming signal and to perform digital filtering. In fact the software performs the Fourier Transform of the incoming signal, useful to make a real time filtering if needed to improve the quality of the ECG. A wavelet filtering is also available. The operator has to evaluate only the frequencies to suppress, after seeing the Fourier Transform of the signal, and the software performs the signal filtering.
The software allows also the creation of hospital files, the forwarding of the acquired tracing by e-mail as well as an automatic reading of the recorded result (automatic diagnosis).

The use of multiple leads gives diagnostic potentialities to the electrocardiogram which are not possible with 3 or 4 leads employed at the present.
The system has been tested and in Fig.2 we have shown a draft of an acquisition example obtained.

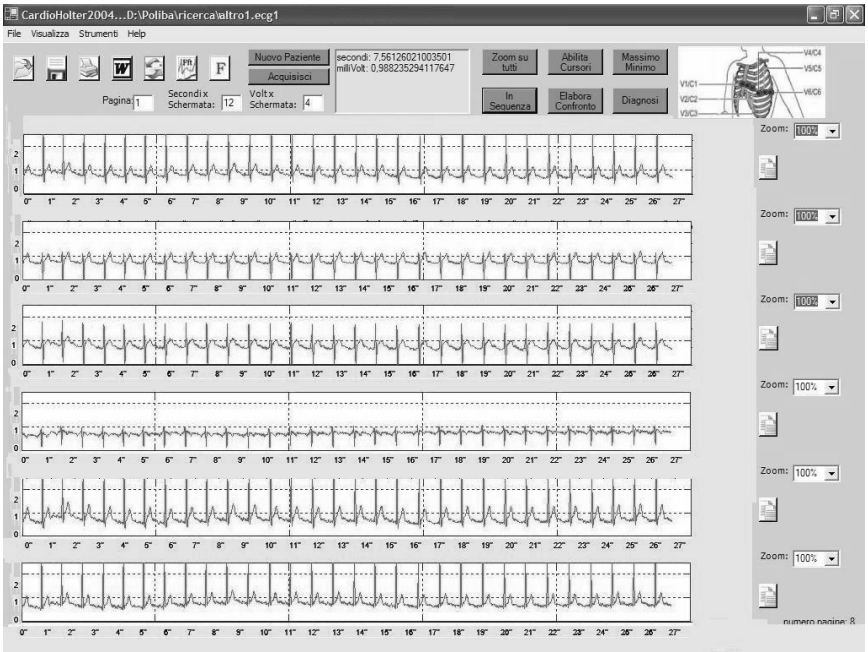

Figure 2. An acquisition example of ECG.

As regards the wireless module to send the data to the recorder/storage unit, Fig. 3 shows the relative prototype, realized at our Electronic Device Laboratory.

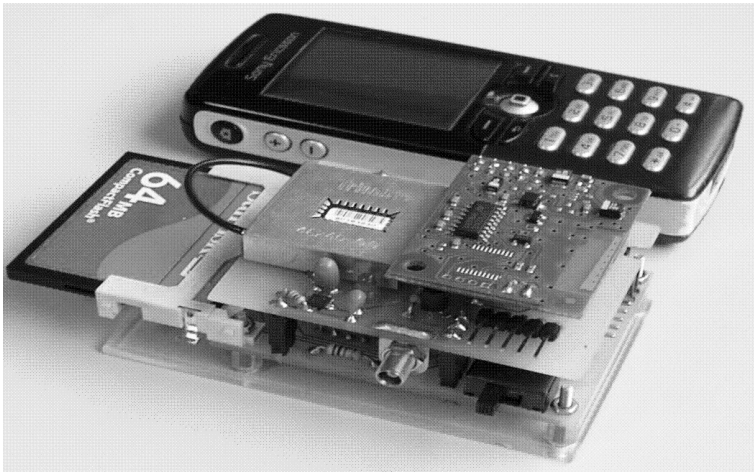

Figure 3. The realized prototype of wireless module for ECG transmission.

It is equipped with GPS module for the patient location in real time.
It proves particularly useful indefinite places such as nursing homes and rest homes for elderly people.
However by using a mobile phone the system also allows transmission within a long range by GPRS/GSM.
The microcontroller permits to implement a diagnostics algorithm and/or to download, in real time, the data by UDP channel.
The tracing can be also stored on flash cards legible with any PC equipped with a reader of flash memories.

III. CONCLUSIONS

In this paper we have presented a new system for ECG transmission by Bluetooth, embedded in a digital cardioholter with multiple leads.
The proposed device presents the following advantages respect to the state of the art:

1. data from up to 12 channels;
2. sensors, embedded in a kind elastic band;
3. possibility to place on the thorax many electrodes without reducing the movement potentials;
4. the elastic band mounting a wireless module (Bluetooth) to send the data to the recorder/storage unit;
5. implementation of a diagnostics algorithm and/or to download, in real time, the data by UDP channel.

The system has been designed, prototyped and tested at the Electronic Devices Laboratory (Electrical and Information Engineering Department) of Polytechnic University of Bari, Italy, within a biomedical research program, with the support of national university medical centre.

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AUTHORS

Roberto Marani received the Master of Science degree (cum laude) in Electronic Engineering in 2008 from Polytechnic University of Bari, where he received his Ph.D. degree in Electronic Engineering in 2012. He worked in the Electronic Device Laboratory of Bari Polytechnic for the design, realization and testing of nanometrical electronic systems, quantum devices and FET on carbon nanotube. Moreover Dr. Marani worked in the field of design, modelling and experimental characterization of devices and systems for biomedical applications. In December 2008 he received a research grant by Polytechnic University of Bari for his research activity. From February 2011 to October 2011 he went to Madrid, Spain, joining the Nanophotonics Group at Universidad Autónoma de Madrid, under the supervision of Prof. García-Vidal. Currently he is involved in the development of novel numerical models to study the physical effects that occur in the interaction of electromagnetic waves with periodic nanostructures, both metal and dielectric. His research activities also include biosensing and photovoltaic applications. Dr. Marani is a member of the COST Action MP0702 - Towards Functional Sub-Wavelength Photonic Structures, and is a member of the Consortium of University CNIT – Consorzio Nazionale Interuniversitario per le Telecomunicazioni. Dr. Marani has published over 100 scientific papers.

Anna Gina Perri received the Laurea degree cum laude in Electrical Engineering from the University of Bari in 1977. In the same year she joined the Electrical and Electronic Department, Polytechnic University of Bari, Italy, where she is Full Professor of Electronics from 2002. From 2003 she has been associated with the National Institute of Nuclear Phisics (INFN) of Napoli (Italy), being a part of the TEGAF project: "Teorie Esotiche per Guidare ed Accelerare Fasci", dealing with the optimal design of resonance-accelerating cavities having very high potentials for cancer hadrontherapy. In 2004 she was awarded the "Attestato di Merito" by ASSIPE (ASSociazione Italiana per la Progettazione Elettronica),

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